STAR FINDER AND IDENTIFIER S-3a

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The new Star Finder and Identifier named S-3a, developed by the author of this paper is designed primarily for use with the American Nautical Almanac. A short description and examples of its use with the star chart No. 8 given here will demonstrate the simplicity and accuracy of this solution of star identification problems.

SHORT DESCRIPTION

This Star Finder comprises 57 selected stars taken from the daily pages of the American Nautical Almanac and the remaining 116 stars taken from the star list near the end of this Almanac, with the addition of a further 9 fainter stars. Thus the stars used for celestial navigation, from practically all the Nautical Almanacs in the world, are shown in this Finder. In fact, it is the second variant of a Star Finder developed by the same author and described in the paper " New Star Finder Superseding the Star Globe " published in January 1963 edition of the *International Hydrographic Review*. This has been modified so as to reduce the number of star charts from 36 to only 18, and primarily to enable its direct application to the American Nautical Almanac and other similar Almanacs (the British, Brazilian, Norwegian, atc.), while retaining the original accurate and simple solution procedure.

A continuous picture of star positions with respect to all values of both the local hour angle of the First Point of Aries and all latitudes of the observer is the desired goal for all star finders. This, however, is difficult to attain except on a star globe, and on board ship this does not prove practical. For the Star Finder under review it is attained by means of 9 pairs of star charts and one template showing the visible hemisphere (horizon system of coordinates). The equatorial stereographic projection is used for the construction of all charts and the template. The plotted parts of the star path on both sides of the plotted star symbol, for the interval of the local hour angle of the First Point of Aries for which the star chart is constructed, give a continuous picture of star positions with respect to all values of Aries LHA in this interval and all positions of the observer.

Each pair of star charts shows the western and eastern hemisphere separately. The stars are plotted with different symbols, according to their magnitude. Selected stars are in black, and other stars in green. The stars in constellation are connected by a dashed yellow line, while the alignments are plotted with solid yellow lines to make orientation in the sky easier. By this differentiation of the type and colour in which the star names in this Star Finder are printed the user can clearly see where he may find the accurate coordinates of the identified star, i.e. either on the daily pages of the American Nautical Almanac for the selected star, or in the star list near the end of this Almanac.

The names of the selected stars are shown in black capital letters, while all other stars are shown in green, using capital letters for regular names and lower case type for astronomical (Bayer's) names.

For other than selected stars it is difficult to find accurate coordinates in the star list near the end of the American Nautical Almanac since this list is not compiled in alphabetical order but in the SHA order. This is why in this Star Finder an alphabetical Index of names of all plotted stars (both selected and others) has been included. In the Index rounded values of SHA and declination are given against the star names in order to facilitate the finding of accurate coordinates for the identified stars (other than selected stars). This is done by using the SHA taken from this Index and the star name, these being the two entering arguments in the star list near the end of the American Nautical Almanac.

Two 20° intervals of the LHA Aries, differing by 180°, are used for constructing each pair of star charts. The circle bordering the star chart and passing through the celestial poles represents the observer's celestial meridian. Outside this circle there is a graduation, positive above the celestial equator and negative below it. This scale is used for orienting the template of the visible hemisphere for the observer's latitude, since the inclination of the zenith above the celestial equator represents the latitude.

The border scale on the right hand half is black, and that on the left is red. By selecting the appropriate pair of star charts according to the values of Aries LHA and to the azimuth, shown respectively on each side of the upper part of the star charts, and by placing the template over the selected star chart in such a way that their centres coincide and that the zenith of the template is placed on the proper latitude value on the black border scale when the azimuth figures are in black (or on the red border scale when the azimuth figures are in red), the altitude and azimuth of stars can be determined, and also vice versa, for, with the observed altitude and azimuth we can determine which star is situated in a particular position.

Star symbols on all the star charts are plotted for odd tens of degrees of the Aries LHA. A part of the star's path is plotted to a distance of 10° to the left and to the right of the star symbol's position. A 10° increase of the Aries LHA is plotted as a path in a solid line, and a 10° decrease of the Aries LHA is plotted as a dotted line. These portions of the star paths facilitate the identification of stars and make for more certainty. In this way, the position of a star, determined by means of altitude and azimuth on the template superimposed on this star chart, may be found from either

the star symbol or the accompanying portions of the star path, and so any confusion in determining the name of the unknown star observed, one which might be used in navigation, is entirely avoided.

PRACTICAL USE

The Star Finder and Identifier S-3a can be used for identification of celestial bodies (either stars or planets) as well as for making an advance list of celestial bodies which may be observed at a given time. Solutions of examples of all these problems are given in this paper as well as a reproduction of star chart No. 8. The scale used for the star charts and the template is large enough to give sufficient accuracy for identification purposes. All explanations and instructions for use are given schematically in simple and short form in the table printed above each star chart and on both sides of the border scale. The main rule is that red azimuth figures refer to the chart's border scale numbered in red, and that black azimuth figures refer to the black numbering, and this rule is clearly printed on either side of the star charts.

If the examples given in this paper were solved by means of some other star finder it would be easy to see which method is preferable. By using this Star Finder the result is always obtained directly, without any additional procedure and without any doubt as to which star has been observed.

Identification of stars

Example 1. — On 25 February 1965, DR position of a ship was Lat. 50°03′ N, Long. 17°15′ W. The navigator observed an unknown star as follows : GMT $19^h33^m22^s$, Alt. 37°43′, Az. 165°. Identify the unknown celestial body by the Star Finder S-3a.

Solution :

From the Nautical Almanac for 1965, date 25 February : For GMT

18^h	Aries GHA	65°23′.0
$1^h33^m22^s$		23 24.4
	Aries GHA	88 47.4
	Long.	— 17 15.0 W
	Aries LHA	71°32′.4

For the Aries LHA value approximately 71°.5 and azimuth 165° the star chart No. 8 will be used. This star chart, with the template already superimposed and oriented for Lat. 50° N, is shown in the illustration

attached to this paper. In the identification procedure, however, before placing the template over it, we can see from the explanation given in the table above the star chart that for Aries LHA 70° the star position will be found on the plotted symbol of a star; for Aries LHA 80° it will be at the end of the solid line of the star's path, and for Aries LHA 60° at the beginning of the dotted line of the star's path. This leads us to the conclusion that for Aries LHA 71°5 the position of the star will be a little removed from the star symbol at the beginning of the solid line of the path. As the azimuth figures shown on the top of the star chart and the template are black (eastern), the zenith of the template should be placed on the black border scale of the star chart in such a way as to cover the value of the latitude, i.e. + 50°.

The intersection of the vertical circle for azimuth of 165° with the altitude parallel of 37°7 (the grid of the template is shown in blue) was found to be at the beginning of the solid line path of the star ALNILAM. Thus the star identified is Alnilam. As its name is shown in black capital letters, we see from the table above the star chart that it is a selected star and, accordingly, its accurate coordinates may be found on the daily page of the American Nautical Almanac if these are required for sight reduction.

Example 2. — Three unknown stars with the following data were observed :

a) Lat. 50°07′ N, Aries LHA 70°, Az. 28°, Alt. 22°48′.

b) Lat. 50°02′ N, Aries LHA 66°5, Az. 29°5, Alt. 25°00′.

c) Lat. 50°03′ N, Aries LHA 61°, Az. 152°, Alt. 26°16′.

Solution :

a) For Aries LHA 70° and Az. 28° the star chart No. 8 will be used (see Annex). From the explanation in the table above the star chart we see that for Aries LHA 70° the star's position will be found to be on the star symbol. As the azimuth figures 28° are in black, the zenith of the template must be placed on the black numbered border scale to cover the latitude of + 50°. At the intersection of Az. 28° and Alt. 22°8 we found the symbol of the star MIZAR. This name is shown in green, therefore it is not a selected star and its accurate coordinates are shown not on the daily page of the American Nautical Almanac but in the star list near the end of this Almanac. For the easier use of this list (i.e. to find the star at once) we will firstly find in the Star Finder's Alphabetical Index of Stars the approximate value of SHA for Mizar; by means of this and the star name we shall easily find the accurate coordinates SHA and the declination for Mizar required for sight reduction, without wasting time in searching for its name in the American Nautical Almanac list.

b) For Aries LHA 66°5 and Az. 29°5 the star chart No. 8 will also be used. The explanation in the table above the star chart shows that for Aries LHA 66°5 the position of the star will be found to be on the dotted line of the star path approximately between the star symbol and the midpoint of that dotted line. Because the azimuth figures are in black the

zenith must be placed on the black figures + 50° on the chart's border scale. The intersection of Az. 29°.5 and Alt. 25° is found to be between the dotted line path of the star Alioth and the solid line path of the star Mizar. As we have already stated in the table that the star's position will be found to be on the dotted line of the star path, the observed star is without doubt ALIOTH, since for Mizar the position on the solid line path corresponds to a value of Aries LHA greater than 70° (i.e. approximately 72°), whilst our value for Aries LHA was 66°.5.

In this example we may see that, even for closely-situated stars in the star chart, identification by this Star Finder may be made easily and with great certainty. This is primarily because of the application of the special system of showing a continuous picture of a star's position by means of plotted portions of the star path, a system not used before for any other star finder. Secondly, greater accuracy is obtained by the use of a larger scale for the star chart (the distance on the chart from the celestial pole to the celestial equator is 98 millimetres), and also by the selection of the equatorial stereographic projection instead of the polar one. Thus for the same star chart dimensions this Star Finder has a scale nearly twice as large.

c) For Aries LHA 61° and Az. 152° the star chart No. 8 will again be used. From explanations given in the table above this chart we see that for Aries LHA 61° the star's position will be found to be at the beginning of the dotted line of the star path. Black azimuth figures correspond to black latitude scale figures, and the zenith of the template is placed over the black + 50°. The intersection of Az. 152° and Alt. 26°.3 is found to be at the beginning of the dotted line of the path of the star SAIPH (k Orionis), whose accurate coordinates we shall find in the star list near the end of the American Nautical Almanac as we did for the coordinates of the star Mizar in example *a*).

Identification of planets

Example 3. — On 30 April 1965, at the latitude 50°02′ N a navigator observed an unknown celestial body with the following data : Aries LHA 75°, Az. 86°.5, Alt. 10°20′. Identify the body.

Solution :

For Aries LHA 75° and Az. 86°.5 the star chart No. 8 will be used (see Annex). The intersection of Az. 86°.5 and Alt. 10°.3 is found to be below the star Regulus and approximately 1 millimetre above the right-hand edge of the letter " R " in the name Regulus. In relation to the position of Regulus for Aries LHA 75° (i.e. to the position on the midpoint of the solid line of its path) the position of the observed celestial body (above the letter R) has a SHA about 10° less than Regulus (to the left), and declination about 2° less. Coordinates for Regulus are obtained from the Nautical Almanac, and by subtracting the estimated differences (— 10° SHA and — 2° dec.) we find the following coordinates for the observed body :

Regulus :	SHA	208°.4	dec.	+ 12°.1
		— 10.0		— 2.0
	SHA	198°.4	dec.	+ 10°.1

From the daily page in the Nautical Almanac for 30 April taking the above coordinates SHA 198°.4 and dec. + 10°.1 we find that the observed body is the planet MARS.

In practice however the procedure is considerably shorter. After approximately estimating that the position of the observed body is in the vicinity of the star Regulus, a glance at the daily page of the Nautical Almanac for 30 April shows the approximate coordinates of Regulus; then with these coordinates a search is made to find which of the four navigational planets has coordinates closest to those of Regulus. We see that only Mars has coordinates close of the values of those of Regulus (Mars SHA 199° and dec. + 10°), whilst Venus is not visible and the SHA of Jupiter is 301° and of Saturn 14° which means that they cannot be considered in this case. This shortened and easy procedure for identification of planets was achieved by the insertion in this Star Finder of a large number of stars (182), i.e. practically all stars which might be used in celestial navigation. The result in practice is that the position of a star determined by means of Az. and Alt. on the template is never to be found on an empty space on the star chart, except when one of the planets is observed or when an error has been made. But if a small number of stars (only selected stars) are plotted in a star finder then whenever the star's position is found to be on an empty space on the star chart there will be doubt as to whether the observed celestial body is a non-charted star or else one of the planets. This creates uncertainty and the necessity of employing yet again the lengthy procedure for identification of stars and planets.

Making an advance list of celestial bodies which could be observed at a given time

Example 4. — On 28 February 1965 during the evening twilight for GMT $19^h26^m31^s$ at the DR position, Lat. 50°04′ N, Long. 15°00′ W, find the approximate azimuth and altitude of each first magnitude star and any navigational planets between altitudes 20° and 60° in the eastern hemisphere.

Solution :

From the Nautical Almanac for 1965, date 28 February : For GMT

18^h	Aries GHA	68°20′.4
$1^h26^m31^s$	.....	21 41.3
	Aries GHA	90 01.7
	Long.	— 15 00.0 W
	Aries LHA	75°01′.7

Selection of stars

For Aries LHA approx. 75° and eastern (black) azimuths the star chart No. 8 will be used. The zenith of the template must be placed on the black + 50° of the latitude scale. Then between altitude parallels 20° and 60°, Az. and Alt. have to be taken out for each first magnitude star for the position of Aries LHA 75° i.e. for the midpoint of the solid line of the star path. From the appended star chart we find in this way :

	Az.	*Alt.*
Pollux	110°0	52°5
Procyon	130.0	34.5
Betelgeuse	161.5	46.0
Sirius	154.0	19.5
Rigel	176.0	31.7

Selection of planets

From the Nautical Almanac for 28 February 1965 we find the following coordinates for planets and their nearest selected stars :

Planets	SHA	Dec.	Nearest selected star	SHA	Dec.	Difference from nearest selected star	
						SHA	Dec.
Venus	not visible	.....	.....	.....	.....	.....	.....
Mars	186°	+ 7°	Regulus	208°	+ 12°	— 22°	— 5°
Jupiter	313	+ 17	Aldebaran	292	+ 16	+ 21	+ 1
Saturn	not visible	.....	.....	.....	.....	.....	.....

If the differences in SHA and Dec. found above are added to the coordinates of the stars mentioned, then from the star chart No. 8 with the template oriented for latitude we find the following :

— Mars is about 5° south of Regulus (approximately 6 millimetres below Regulus) and about 22° left of Regulus (i.e. somewhat more than twice the dotted line path's length to the left of Regulus). Accordingly Mars is in the vicinity of the horizon and has an altitude of less than 20° and thus it does not come into consideration.

— Jupiter has a SHA about 21° to the right of Aldebaran (i.e. for about the full length of the dotted and the solid star path lines to the right). This means that Jupiter is not on this particular star chart (eastern hemisphere) but on the star chart No. 7, and thus does not come into consideration.

In this way, by means of estimated coordinates of the planets, and without precise plotting, it can be ascertained whether or not any of the four planets comes into consideration. The plotting of the position of a planet can then follow, as well as the portions of its path on both sides for + and — 10° of SHA according to the estimated length of these lines of the nearest plotted stars. With the planets plotted in this way the approximate *Az.* and *Alt.* coordinates can be read in order to find the planets easily in the sky in the same way as has been done in the example for the stars.

CONCLUDING NOTE

This Star Finder and Identifier S-3a has not yet been issued. It can be printed either on the paper used for nautical charts, with an additional plastic template, or else on 10 white opaque plastic sheets for star charts, including appropriate technical facilities such as a small centre hole in the star charts and a small peg in the centre of the template for setting and rotating the template more easily. The fashion in which such a manual for star identification will finally be issued will depend on arrangements made between the author of the Star Finder and the publisher interested in it. Regarding a Nautical Almanac differing from the American Almanac, this Star Finder could be further modified in order to make the use of the Star Finder more convenient.